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# 甘肃东乡龙担的长鼻三趾马头骨化石
## ——龙担哺乳动物群补充报道之三[1)]

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**摘要**:报道了在甘肃省东乡县龙担地点发现的中国长鼻三趾马 *Hipparion*（*Proboscidipparion*）*sinense* 头骨化石。此前在早更新世龙担动物群中记述过的长鼻三趾马材料仅有一枚第三掌骨,头骨化石的发现不仅使该动物群的三趾马种级分类得到证实,同时扩大了对这个种头骨和牙齿特征的认识。由于最初建种的正型标本为老年个体,此后也未发现过中国长鼻三趾马的完好头骨化石,因此龙担的新材料将为该种的特征补充更多重要的信息,尤其是鼻切迹的构成。其鼻骨下部呈一细窄条状向前强烈延伸,组成鼻颌切迹下缘的后部,其前端尖,到达P2/P3界线水平,与前颌骨鼻突的末梢间有30 mm的距离。这些特征的识别对判断长鼻三趾马的系统关系有重要意义。

**关键词**:甘肃临夏盆地,早更新世,马科,三趾马

**中图法分类号**:Q915.877 **文献标识码**:A **文章编号**:1000－3118(2012)01－0074－11

# A SKULL OF *HIPPARION* (*PROBOSCIDIPPARION*) *SINENSE* (PERISSODACTYLA, EQUIDAE) FROM LONGDAN, DONGXIANG OF NORTHWESTERN CHINA
## —Addition to the Early Pleistocene Longdan Mammalian Fauna (3)

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**Abstract** A skull of *Hipparion* (*Proboscidipparion*) *sinense* is reported from the Longdan locality in Dongxiang, Gansu Province, northwestern China. The previously known material of *H.* (*P.*) *sinense* in the Early Pleistocene Longdan fauna was only a metacarpal III. The discovery of this skull not only confirms the specific identification of *Hipparion* in this fauna, but also increases the understanding of the cranial and dental characters of this species. The holotype specimen of *H. sinense* belongs to a senile individual, and no other complete skull of this species has been found. As a result, the new material from Longdan provides more key information for the diagnoses of *H. sinense*, and the structure of the nasal notch of this species becomes clear. The lower part of the nasal bone is a tenuous strip that extends far forward, comprises the posterior part of the lower margin of the nasal notch, and has a sharp anterior end reaching the level of the P2/P3 boundary, at a 30 mm distance from the posterior end of the nasal process of the premaxillary bone. The recognition of these characters is of great interest in determining

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the phylogenetic relationship of *Proboscidipparion*.

**Key words** Linxia Basin, Gansu, China; Early Pleistocene; Equidae; *Hipparion*

*Proboscidipparion* is a derived, large- to giant-sized form of the three-toed horse with a special muzzle structure, and its nasal notch reaches deeply above the middle part of the cheek tooth row (Sefve, 1927). There are two known species of *Proboscidipparion*: *Hipparion* (*Proboscidipparion*) *sinense* and *H.* (*P.*) *pater*. The distribution of *Proboscidipparion* was previously limited to northern China (Qiu et al., 1987), but recent studies expanded its distribution to as far as England (Forsten, 2001).

The genus *Proboscidipparion* was created by Sefve (1927) on the basis of a senile skull (M 3925) from Langou (Lankou, Loc. 39) in Mianchi County, Henan Province, China, and its type and only species was *P. sinense*. But the holotype's teeth, with the exception of P4 and M3, are heavily worn. The specimens of *Proboscidipparion* from Nihewan in Yangyuan County, Hebei Province, are juvenile cranial materials that led Teilhard de Chardin and Piveteau (1930) to reduce *Proboscidipparion* to a subgenus of the genus *Hipparion*. Qiu et al. (1987) referred *Hipparion richthofeni* mut. *pater*, which was established by Matsumoto (1927), into this subgenus, i. e., *H.* (*P.*) *pater*, and they described the fossils of the Pliocene and Early Pleistocene *Proboscidipparion* found from the Yushe Basin in Shanxi Province. Among them, *H. pater* has rich skull materials, but *H. sinense* includes only a few isolated teeth. Moreover, postcranial bones of *Proboscidipparion* were found in Yushe. Forsten (1997) mentioned a skull of *H. sinense* from the Yushe Basin without number and precise locality data at the Beijing Museum of Natural History, but she did not provide any description of this specimen. The fossils of *Proboscidipparion* found in other localities also include mainly teeth and fragmented mandibles. As a result, not much was known about the skull of *H. sinense* in the past. Qiu et al. (2004) reported the Early Pleistocene fauna found at Longdan in Dongxiang County, Gansu Province, including a third metacarpal of *H. sinense*. The new collection at the Hezheng Paleozoological Museum has a relatively complete skull of *Proboscidipparion*. In the present paper, the Longdan skull of *Proboscidipparion* is described and compared in detail, not only confirming the specific identification of *Hipparion* in the Longdan fauna but also providing more information about the cranial and dental characters of *H. sinense*. Because this skull belongs to a juvenile individual, most of its sutures can be distinguished and compared with the skulls of *H. pater* in greater detail.

The anatomical terminology for the fossil description is according to Sisson (1953), and the measurements are according to Eisenmann et al. (1988). Abbreviations: HMV: the vertebrate collection of the Hezheng Paleozoological Museum, Hezheng, Gansu; THP: the collection of the Tianjin Natural History Museum, Tianjin; V: the vertebrate collection of the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP), Chinese Academy of Sciences, Beijing; M: the collection of the Evolution Museum of Uppsala University, Uppsala, Sweden; LX: the locality number of IVPP in the Linxia Basin, Gansu.

## Family Equidae Gill, 1872
### Genus *Hipparion* de Christol, 1832
#### Subgenus *Proboscidipparion* (Sefve, 1927)
#### *Hipparion* (*Proboscidipparion*) *sinense* (Sefve, 1927)

(Figs. 1 – 3; Tables 1 – 2)

**Described specimen** HMV 1872, a juvenile skull. Its M3 is not erupted, DP2 is only just lost, and DP3 and DP4 still are in use. Most sutures are not fused.

**Locality and horizon** Shitougu (LX 0201) in Nalesi Town, Dongxiang County, Gansu Province. The lower part of the Early Pleistocene Wucheng Loess (see Qiu et al., 2004).

**Description** The skull is somewhat compressed laterally so that most transverse measurements are unavailable. Otherwise, the state of its preservation is quite good, permitting reasonably accurate length measurements of the bony portions (Table 1) and excellent measurements

of the cheek teeth (Table 2). It is a male individual with an erupted large-sized canine. Its age is approximately 2.5 years determined by the eruption of its cheek teeth (Qiu et al., 1987:25).

The skull is dolichocephalic and has a narrow muzzle (Figs. 1, 2). Its roundly square orbits are 67 mm long and 50.5 mm high. The bottom of the nasal notch is located above the M1/M2 boundary.

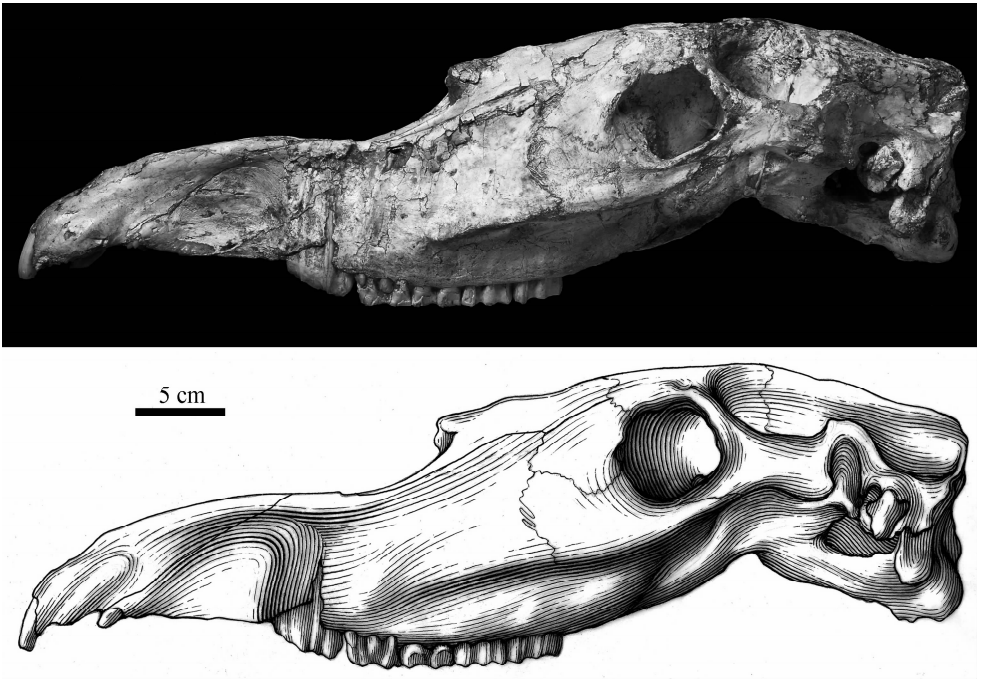


Fig. 1 Lateral view of the skull of *Hipparion* (*Proboscidipparion*) *sinense* from Longdan, HMV 1872

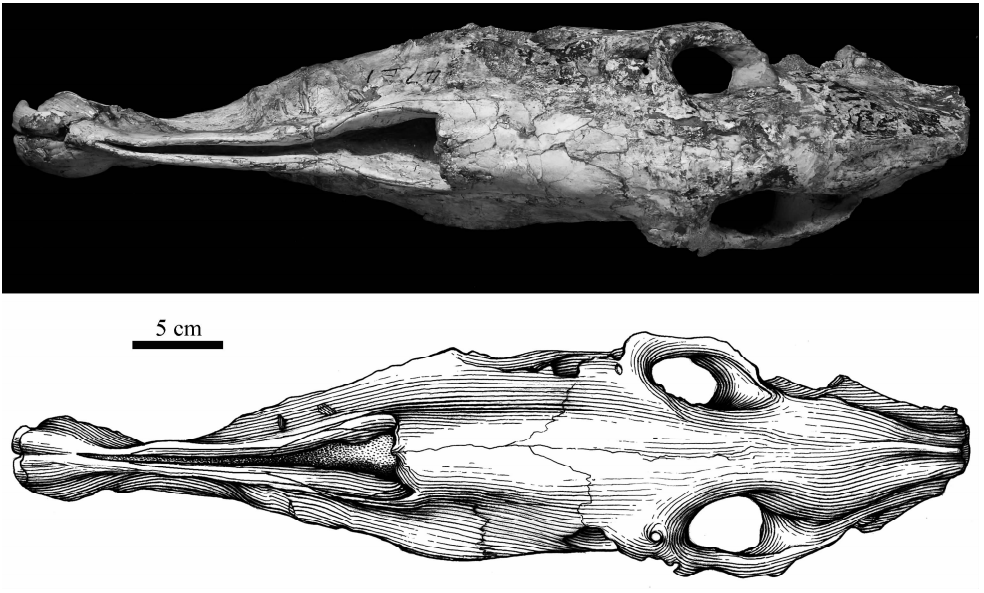


Fig. 2 Dorsal view of the skull of *Hipparion* (*Proboscidipparion*) *sinense* from Longdan, HMV 1872

The basioccipital is narrow and high, with a short, thin and sharp sagittal crest. The ventral part of the occipital condyle is long, and its anterior end is at the same level as the anterior margin of the paroccipital process. The intercondyloid notch is narrow and has a deep groove, extending anteriorly and reaching the terminal joint of the occipital condyles. The basilar tubercles are well-developed and laterally prominent, with midline located at the level of the anterior margin of the foramen lacerum. The paroccipital process is compressed and inclined postero-laterally, with an angle of 45° to obliquely cross the sagittal plane. The hypoglossal foramen is large and rounded, with a diameter of 13 mm (Fig. 3A).

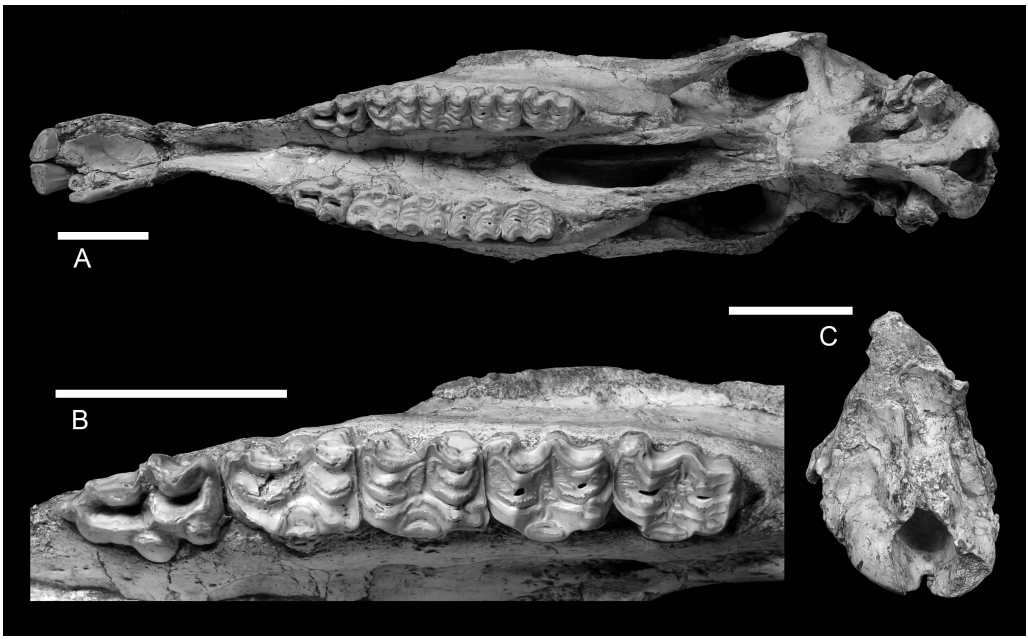


Fig. 3　Skull and cheek teeth of *Hipparion* (*Proboscidipparion*) *sinense* from Longdan, HMV 1872
A. skull in ventral view; B. cheek teeth in occlusal view; C. skull in occipital view; scale bars = 5 cm

The occipital surface is nearly triangular and especially narrow and high because of the laterally compressed deformation (Fig. 3C). The middle part of the nuchal crest diverges distinctly downward and overhangs backward, with a width of 44 mm. The lateral part of the nuchal crest extends antero-inferiorly and divides into three clear crests above the mastoid process (Fig. 1), which is a common character of *Proboscidipparion* (Qiu et al., 1987:33, fig. 15). The temporal crest is straight. The nuchal ligament fossa is an inverse and shallow triangle, and its lower end is above the upper margin of the foramen magnum. The lateral crests are wide and rounded, and the protuberantia supramagna (Qiu et al., 1987:10, fig. 1) is strong. The nuchal tuberosity is weak. The nuchal surfaces lateral to the nuchal ligament fossa are widely triangular and face postero-laterally, with an angle of 45° to cross the occipital surface. The foramen magnum is rounded and would be perhaps higher than wide without deformation. The occipital part of the occipital condyle is smaller than the ventral part. The supracondyloid fossa is large and deep, located laterally above the occipital condyle (Fig. 3C).

The sphenoid body is narrow and high ventrally. The base of the pterygoid process is anteriorly located at the level in front of the temporal condyle. The pterygoid crest is weak and diverges slightly laterally. The temporal wings are rough and uneven. The pterygoid groove is wide and shallow. The foramen lacerum is large (Fig. 3A).

The zygomatic processof the temporal bone is relatively high in lateral view, and the temporal condyle projects laterally. There is a distance of approximately 10 mm between the anterior margin of the temporal condyle and the posterior margin of the postorbital process (Fig. 1), which is identical in *H. pater* (Qiu et al., 1987:33, fig. 15). The anterior end of the zygoma tic process extends to the anterior part of the lower orbital margin. The temporal condyle is transversely narrow and long, strongly convex, laterally wider, and narrowest at the middle, the inner end of which extends posteriorly as a long, narrow triangular process. The postglenoid process is short, medial to which is a triangular impression and behind which is a deep rounded depression with a large and rounded postglenoid foramen on its bottom (Fig. 3A). The temporal crest on the posterior process of the squamous temporal is pointed upward vertically, and then extends forward to be arched and connects to another temporal crest from the mastoid process (Fig. 1).

The tympanic bulla of the petrous bone is antero-posteriorly narrow and wheel-like (Fig. 3A). The external auditory process has an angle of 45° to the vertical plane, 26.5 mm long, and 14 mm wide, with a clear crest on the postero-ventral side. The external auditory meatus is rounded, with a diameter of 7.5 mm. The hyoid process is robust and slightly flat, with a major diameter of 9.3 mm. The upper half of the mastoid process is a strip exposed between the occipital bone and the posterior process of the squamous temporal, and the lower half is expanded to form a cylinder located at the antero-lateral side of the paroccipital process, with an antero-posterior length of 24 mm, and combining with the base of the paroccipital process (Fig. 1).

The posterior roof of the skull is somewhat damaged, but the sagittal crest can be discriminated, with the parietal crests dividing at least at the level of the midline of the glenoid fossa (Fig. 2). The central flat part of the dorsal surface of the frontal bone is narrow, and the lateral parts are inclined so that the supraorbital foramen and the upper orbital margin are lower than the frontal surface. The postorbital process is transversely wide, anteriorly concave, posteriorly convex, and relatively thin in lateral view.

The free parts of the nasal bones are lost, and the posterior parts are long and strongly inclined laterally, with a length of 101 mm. The lower part of the nasal bone has a narrow and long strip to extend forward, comprising the posterior part of the lower margin of the nasal notch, the anterior end of which is sharp and reaches above the P2/P3 boundary, with a distance of 30 mm from the tip of the nasal process of the premaxillary bone (Fig. 1).

The facial surface of the lacrimal bone is irregularly pentagonal, smooth, large, and located at the antero-superior corner of the orbit, with an antero-posterior length slightly shorter than that of the orbit (Fig. 1). The lacrimal sac fossa is rounded and located at the antero-superior corner of the orbital surface. The corresponding lacrimal tubercle on the upper part of the anterior orbital margin is well developed. The anterior half of the upper orbital margin is a wide and deep notch.

The zygomatic process of the zygomatic bone reaches the posterior orbital margin. Its ventral surface is wide, and its lateral side is a rough surface for muscular attachment. This character is the same as that of *Equus* but different from that of *H. pater* (Qiu et al., 1987:34).

The midpoint of the posterior border of the hard palate is located at the level of the anterior end of the M2 protocone, the anterior palatine foramen is at the level of the midline of the M2 protocone, and the palatine groove is weak. The pterygoid process of the pterygoid bone is low and erect, with a central groove. The vomer is thin and sharp, with a long distance from the palatine surface. The vomer notch is narrowly V-shaped, anteriorly shifted, and located in the posterior part of the pterygoid valley (Fig. 3A).

**Table 1　Measurements and comparison of skulls of *Proboscidipparion***　(mm)

| Species | *Hipparion* (*Proboscidipparion*) *sinense* | | *H.* (*P.*) *pater* | |
|---|---|---|---|---|
| Locality | Longdan | Langou | Yushe | |
| Number | HMV 1872 | M 3925 | THP 14312 | THP 20763 |
| Age | ~2.5 years | ~12 years | ~3.5 years | ~5 years |
| 1. Muzzle length | 137 | 133.1* | 120.7 | 119.2 |
| 2. Palatal length | 135.5 | 143.7* | 128.5 | 123.9 |
| 3. Vomer length | 112.5 | 117.1* | 90.2 | 88.7 |
| 4. Post-vomer length | 122 | 107.8* | 114.3 | 102.4 |
| 5. Post-palatal length | 230 | 224.9* | 198 | 185 |
| 6. Basilar length | 502 | 503 | 443 | 425 |
| 7. Premolar length | 98.5 | 89* | 87.2 | 85.6 |
| 10. Choanal length | 83.5 | — | 67 | 68.5 |
| 14. Minimal muzzle breadth | — | 43 | 34.2 | 31.8 |
| 15. Muzzle breadth | — | 66 | ~52.3 | 46.1 |
| 16. Length of temporal fossa | 83 | 74.5* | ~49.5 | 46.8 |
| 17. Length between basion and EF | 137.5 | 141.1* | 129.5 | 118 |
| 18. Frontal breadth | — | 205 | 149.5 | 155 |
| 19. Bizygomatic breadth | — | 198 | — | 156 |
| 23. Anterior ocular line | 368 | 401.9* | 351 | 339 |
| 24. Posterior ocular line | ~190 | 183.6* | 175 | 143.9 |
| 26. Cranial height | 112 | — | 95 | 95.1 |
| 27. Exterior height of EAM | 7.5 | 14.5* | 12.2 | 10.2 |
| 28. Orbital length | 67 | ~63 | 64.1 | 57.4 |
| 29. Orbital height | 50.5 | ~43 | 53.6 | 48.3 |
| 30. Length of nasal notch | 272 | — | 253 | 231 |
| 31. Cheek length | 82 | — | 54.4 | 50.5 |
| 37. Height of PF above AB | 78 | ~70 | 66 | 62.3 |

Abbreviations: AB. alveolar border; EF. ethmoidal foramen; EAM. external auditory meatus; PF. preorbital fossa. * measured on figures.

There is no preorbital fossa on the face. The facial crest ends above the middle of P4, with a distance of 37 mm from the alveolar border. The infraorbital foramen is located above the P3/P4 boundary and near the upper border of the maxillary bone, with distances of 11 mm from the lower margin of the nasal notch and 78 mm from the alveolar border at the midpoint of this foramen's posterior border. The P3 root is exposed at the broken infraorbital foramen so that the height of the unworn P3 is measured as 77 mm, much higher than that of *H. pater* (highest: 62.2 mm, Qiu et al., 1987:51). There is a distance of 119 mm between the infraorbital foramen and the orbit (Fig. 1). M3 has not erupted, and the length of the maxillary tuberosity is approximately equal to the length of M1 + M2 under this situation. The alveolar tuberosity is weak (Fig. 3A). The foramen fossae is tiny, antero-posteriorly narrow and long, located on the

postero-superior part of the maxillary bone, and near the suture between the maxillary and the nasal bones. A 30 mm sector of the upper margin of the maxillary bone comprises the middle part of the lower margin of the nasal notch, and extends a very narrow strip afterward so that the lower part of the nasal bone is sandwiched between this strip and the upper border of the maxillary bone (Fig. 1). The maxillary bone comprises most of the lateral wall of the nasal cavity. The facial surface of the maxillary bone is strongly constricted in front of P2 to form a large and deep buccinator fossa. In the dorsal view, the nasal cavity is relatively narrow in front and wide behind (Fig. 2). The lower margin of the nasal notch is thick in front, and becomes narrow behind, with the overlapping thickness of the maxillary bone and the lower branch of the nasal bone still small.

The intermaxillary process is absent. The lower margin of the premaxillary body is straight, and the nasal processes are very close to each other in front. The foramen incisivum is small. The nasal process gradually becomes slender posteriorly and disappears above the midline of P2 in lateral view. Because the terminal position of the nasal process of the premaxillary bone was not determined on the Langou specimen (Sefve, 1927:58), the Longdan skull can aid in determining this character. The interalveolar space (diastema) is 103 mm long.

For the incisors, the I1 cup has an open labial margin, thin enamel, and fine lingual wrinkles. The labial surface of I1 has two wide and shallow grooves, deeper for the medial one. I1 is 19 mm wide, 10 mm long, and 35 mm high. I2 has not erupted. DI3 has a low crown, a posteriorly open cup, and a smooth labial surface without a groove. DI3 is 6 mm wide, 11.5 mm long, and 14.6 mm high.

The canines are just erupted. The crown of the right canine can be observed. It has anterior and posterior wing-like ridges that are located lingually.

DP1 is absent (Fig. 3B). The cheek teeth gradually become smaller from P2 to M2 (Table 2).

P2 is almost unworn. The anterostyle is narrow and long, and the para-, meso-, and metastyles are narrowly prismatic. The protocone is narrow and long, with a convex lingual border. The hypoconal groove is deep, the hypoconal constriction is marked, and the hypocone extends posteriorly to reach the posterior margin of the tooth. The anterior labial valley is wide and shallow, whereas the posterior one is narrow and deep.

DP3 has been heavily worn so that it is close to the root. The parastyle is wide, with a middle groove. The mesostyle is narrow and posteriorly oblique. The labial walls of both para- and meta-cones are deeply concave. The protocone is short, wide, and deeply sunken between the protoconule and the hypocone, with a flat lingual border.

DP4 is similar to DP3. More characters can be observed on DP4. The plications of the pre- and post-fossettes are dense and long. The lingual one of plis protoloph is long, and the others are short. The pli protoconule is bifurcate. Four plis prefossette are densely arranged. The plis postfossette become shorter from lingual to labial. The hypoconal groove is shallow, and the hypoconal constriction is weak. The protocone is long, with a slightly concave lingual border. The pli caballine is single, short and small.

For M1, the parastyle is wide, with a deep middle groove. The mesostyle is narrow. The labial walls of the para- and meta-cones are concave in a semicircle, deeper for the paracone and wider for the metacone. The protocone is extremely narrow, with a flat lingual border. The pli caballine is single, robust, and erect. The plications of the pre- and post-fossettes are denser and longer, and their lingual walls are finely denticulate. The prefossette is almost full of plications. There are five plis protoloph, among which the lingual one is bifurcate in a Y-shape. The pli protoconule is robust, with a bifurcate tip. There are three plis prefossette, among which the labial one is bifurcate in a Y-shape. There are three plis postfossette, among which the lingual and labial ones are bifurcate, and the middle one is short. The middle pli hy-

postyle is long and oriented 45° antero-labially; the others are fine and dense. The hypoconal groove is deep, the hypoconal constriction is marked, and the hypocone is sharp and does not reach the posterior margin of the tooth. The anterior horn of the postfossette is still obviously higher than the posterior horn of the prefossette.

M2 is very similar to M1 in shape, with a slightly smaller size and a longer protocone. Because M2 is weakly worn, the posterior wall of the postfossette is open, and the plications on this wall have not appeared.

**Table 2　Measurements and comparison of upper cheek teeth of *Proboscidipparion*** (mm)

| Species | | *Hipparion* (*Proboscidipparion*) *sinense* | | | | *H.* (*P.*) *pater* | |
|---|---|---|---|---|---|---|---|
| Locality | | Longdan | Langou | Nihewan | | Yushe | |
| Number | | HMV 1872 | M 3925 | THP 00149 | No number | THP 14312 | THP 20763 |
| Age | | ~2.5 years | ~12 years | ~2 years | ~1.5 years | ~3.5 years | ~5 years |
| P2 | L × W | 40.5 × 24.6 | 40 × ~25 | 50 × 25* | 43 × 23* | 35 × 23.3 | 34.5 × 22.5 |
| | Pro. L × W | 10.8 × ? | ~8 × — | 7.2 × 4 | 6.9 × 3.9 | 5.9 × 4.1 | 7.8 × 3.5 |
| | Pro. Index | 26.67 | ~20 | 14.4 | 16.05 | 16.86 | 22.61 |
| P3 | L × W | 30 × 24.1* | 30 × ~25 | 34 × 27* | 31 × 22* | 26.2 × 22.7 | 25.8 × 22.6 |
| | Pro. L × W | 8.2 × 6.9 | 10.8 × ~6.5 | 8.6 × 4.4 | 8.5 × 4 | 5.8 × 4.1 | 6.5 × 3.8 |
| | Pro. Index | 27.33 | 36 | 25.29 | 27.42 | 22.14 | 25.19 |
| P4 | L × W | 28.4 × 21* | 24.5 × 25 | 37 × 25* | 31 × 22* | 24.5 × 21.6 | 24.7 × 22.4 |
| | Pro. L × W | 9.7 × 5.2 | 11 × 6 | 8.3 × 4.2 | 8.3 × 3.7 | 6.7 × 3.1 | 6.8 × 3.6 |
| | Pro. Index | 34.15 | 44.9 | 22.43 | 26.77 | 27.35 | 27.53 |
| M1 | L × W | 29 × 22 | 23.5 × 25 | 29.9 × 26.8 | 28 × 19.5 | 22.9 × 21.8 | 23.3 × 22.8 |
| | Pro. L × W | 8.5 × 3.8 | 9.7 × — | 8.7 × ? | 8.4 × ? | 7.4 × 3.3 | 6.8 × 3.5 |
| | Pro. Index | 29.31 | 41.28 | 29.1 | 30 | 32.31 | 29.18 |
| M2 | L × W | 26.8 × 19.6 | 24 × 23 | 29.4 × 24 | — | 23.5 × 20 | 22.8 × 21 |
| | Pro. L × W | 10 × 3.5 | 10 × 5.5 | 10.2 × ? | — | 7.5 × — | 6.3 × 3.9 |
| | Pro. Index | 37.31 | 41.67 | 34.69 | — | 31.91 | 27.63 |

Abbreviations: L. length; W. width; Pro. protocone. * deciduous teeth.

**Discussion**　Sefve (1927) did not clearly list the characters of *Proboscidipparion sinense*, but he emphasized some characteristic features in his description: 1) *P. sinense* is especially large in size, the largest among the known species of *Hipparion*; 2) it has a unique nasal and muzzle structure with characters that are absent in the other known species of *Hipparion*; and 3) it has very strong plications on the upper cheek teeth. Subsequently, Teilhard de Chardin and Piveteau (1930) described the fossils of *Proboscidipparion* from Nihewan, Hebei, but they stated "La grande taille de ces forms et la présence d'une trompe ou d'un rudiment de trompe ne nous paraissent pas suffisantes pour établir un genre nouveau". As a result, *Proboscidipparion* was reduced to a subgenus. Qiu et al. (1987) provided more evidence to support its subgeneric position, which is adopted in the present paper. They referred *Hipparion richthofeni* mut. *pater* into *Hipparion* (*Proboscidipparion*) *pater* and reported new materials of this species from the Yushe Basin. Therefore, *Proboscidipparion* has had two species up to now. According to the revisions of Qiu et al. (1987), *H. pater* also comes from Loc. 5 north of Baode, Shanxi (Teilhard de Chardin and Young, 1931) and Youhe in Weinan, Shaanxi (Xue, 1981), and its age is Pliocene. *H. sinense* also comes from Bajiazui in Qingyang, Gansu (Wang et al., 1966; Wang and Xue, 1982), Banqiao in Heshui, Gansu (Zheng et al., 1975), Kehe in Ruicheng, Shanxi (Chia et al., 1962), Yangguo in Weinan, Shaanxi (Chi, 1975), and Tuozidong in Nanjing, Jiangsu (Dong and Fang, 2005). The age of *H. sinense* is Early Pleistocene.

This leaves little room for doubt that the Longdan skull should be classified in the subgenus *Proboscidipparion* because of its extremely derived nasal and muzzle structure. The skull from

Longdan is very similar to that of *Hipparion* (*Proboscidiparion*) *sinense* in morphology and structures of the skull, incisors and cheek teeth. Moreover, the Longdan skull's size is within the variation range of this species, so it should be identified as *H.* (*P.*) *sinense*.

Sefve's sole specimen is a senile skull. However, the Longdan specimen shares many identical characters, such as cranial morphology and measurements, with *H. sinense* instead of *H. pater*. Qiu et al. (1987) made several important observations about these characters, which we will now discuss. *H. sinense* has smaller orbits relative to its skull. The ratio (×100) between the orbit length (67 mm) and the cranial basal length (502 mm) of the Longdan skull is 13.35. The ratio for *H. sinense* (68/503) is 13.52, and the ratio for *H. pater* (64.1/443) is 14.47. Forsten (1997) considered the smaller orbits of *H. sinense* attributable to allometry, but the Longdan specimen obviously supports Qiu's judgment. *H. sinense* is also 1/7 longer than *H. pater* in skull basilar length. Forsten considered that this character is age-dependent and differentiated the senile holotype skull of *H. sinense* from the barely adult skulls of *H. pater*. The skull of *H. sinense* from Longdan belongs to a juvenile individual with a basilar length of 502 mm (Table 1), which is still 1/7 longer than that of *H. pater*, which supports Qiu's argument. Qiu et al. (1987) stated that the facial part of *H. sinense* is comparatively low, which means that its nasal bones are near the upper margins of the maxillary and premaxillary bones, whereas the nasal bones of *H. pater* are far from the lower margin of the nasal notch. Forsten (1997) indicated that this situation is attributable to vertical distortion of the type skull of *H. sinense*. Based on the Longdan skull, Forsten's comment is correct. In the dorsal view, the bony nostril in *H. sinense* widens posteriorly to a greater extent than in *H. pater*. Furthermore, the nasal process in *H. sinense* thins out posteriorly more suddenly than in *H. pater*. The foramen incisivum in *H. sinense* is more reduced than in *H. pater* (Qiu et al., 1987). The Longdan skull agrees with these characters of *H. sinense*.

Qiu et al. (1987) indicated that Sefve's description of the basicranium of *H. sinense* was sparse, and his specimen belonged to a senile individual so that most of its sutures had been fused. The Longdan skull can sufficiently supply these characters, and more differences between *H. sinense* and *H. pater* can be found. These differences include weak pterygoid processes of the sphenoid, pterygoid, and palatine bones in *H. sinense* (strong in *H. pater*); the anterior end of the zygomatic process of the temporal bone extending to the anterior part of the lower orbital margin (middle part in *H. pater*); a marked crest on the lateral surface of the external auditory meatus (none in *H. pater*); the lower branch of the nasal bone comprising the posterior part of the lower margin of the nasal notch (no lower branch in *H. pater*); a relatively large facial part of the lacrimal bone with a roughly equal length in the orbit (half of the orbit length in *H. pater*); and a rough surface for muscular attachment on the lateral part of the ventral surface of the zygomatic process of the zygomatic bone (none in *H. pater*).

The holotype described by Sefve (1927) has much-worn teeth so that their characters are difficult to compare with those of the Longdan specimen in detail. However, both specimens still share some features, such as dense plications, wide parastyles, narrow and long protocones, deeply concave labial walls of the para- and meta-cones, and a distinctly higher anterior horn of the postfossette than the posterior horn of the postfossette on the molars. In contrast to the Longdan specimen, the Langou specimen is pressed dorsal-ventrally in taphonomy, so the former can provide some precise dorsal-ventral measurements to complement the latter (Table 1).

The upper cheek teeth from Nihewan described by Teilhard de Chardin and Piveteau (1930) are deciduous, so they can be compared with those of the Longdan specimen. The deciduous teeth of Nihewan and Longdan, especially DP4, are identical with regard to plications, protocones, and parastyles.

The teeth of the Longdan specimen have high crowns, identical to those of *H. sinense* and

obviously higher than those of *H. pater*, and the Longdan specimen has a large size (Table 2), with a P2 – M2 length of 154 mm, which is the same as that of the Langou specimen, whereas a P2 – M3 length of *H. pater* is only 153.7 mm (Qiu et al., 1987:52). The vertical grooves on the labial surface of the upper incisors are distinct in the Longdan specimen but weak in *H. pater*. The parastyle is wider in the Longdan specimen, which is clearly demonstrated by the comparison between M1s of the Longdan specimen and *H. pater* (Qiu et al., 1987:fig. 13). The Longdan teeth have longer protocones and larger protocone indices (Table 2). Among the differences listed by Qiu et al. (1987:52), the number of plications, shape of the pli caballine, and morphology of the anterior horn of the prefossette in the Longdan specimen are similar to those in *H. pater*. The sizes of the Longdan teeth are also smaller than those of *H. sinense* from Yushe and Nihewan. These features appear to indicate that the Longdan specimen is slightly more primitive than other *H. sinense*, which is consistent with its Early Pleistocene geological age.

Forsten (2001) described *Proboscidipparion* sp. from Suffolk, England. But her specimens are only three lower cheek teeth so that they are impossible to compare with the Longdan specimen.

The phylogenetic relationship of *Proboscidipparion* has not been recognized. The Asian *Hipparion dermatorhinum* and *H. forstenae*, and the European *H. proboscideum* all have deep nasal notches, with a posterior edge retracted to the level of P4, but their nasal notches are shallower than that of *Proboscidipparion*. Therefore, Qiu et al. (1987) in noting these similarities, considered large gaps to exist between them. In South America, both *Hippidion* and *Onohippidium* are characterized by a large body size and a greatly retracted nasal notch, in which the nasal bones are delicate, elongated splints. But they belong to a separate tribe (Equini) that is different from the tribe Hipparionini including *Proboscidipparion* (MacFadden, 1992). The retracted nasal notch evolved independently at least twice. Comparing the Longdan skull of *Hipparion* (*Proboscidipparion*) *sinense* with *H. dermatorhinus*, they share several characters, such as the widely exposed lacrimal bone on the facial surface, deep buccinator fossa, sharp nasal process of the premaxillary bone between the nasal and maxillary bones, and well developed lateral part of the nasal bone surrounding the nasal notch, which support the phylogenetic relationship between *Proboscidipparion* and *H. dermatorhinus*.

Judging from the primitive characters of the Longdan skull and the stratigraphical distribution of *Proboscidipparion*, the Wucheng Loess at Longdan should be deposited in the Early Pleistocene, which is consistent with the chronological analysis of the Longdan mammalian fauna (Qiu et al., 2004). Sefve (1927) indicated that *Proboscidipparion* might prefer to live in an area with abundant water, similar to tapirs, which have a similar nasal structure. The discovery of *Proboscidipparion* at Longdan further supports the environmental implication of Wang (2005) in her study of the beaver in the Longdan fauna, which indicates streams and small lakes for the environment of the Linxia Basin during the Early Pleistocene.

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